Point-of-care ultrasound in the modern era of emergency medicine: a narrative review of the recent literature

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Purpose of review
Point-of-care ultrasound (POCUS) has transformed emergency medicine by providing a noninvasive, accessible, repeatable, efficient, and cost-effective imaging tool to the bedside. This article is a narrative review of the most impactful POCUS literature over the past 18 months, identifying and highlighting the most common emerging themes.

Recent findings
We identified five main themes in the recent POCUS literature: ultrasound-guided regional anesthesia, POCUS in resuscitation, diagnostic POCUS, technology and artificial intelligence, and POCUS governance and administration.

Summary
The recent body of literature strengthens the utility of POCUS in emergency medicine, demonstrating its efficacy, safety, and efficiency across multiple clinical scenarios. The literature continues to expand the scope of POCUS by covering new diagnostic applications and integrating emerging technologies, while continuing to build a robust governance framework. Future research should focus on patient-oriented outcomes, implications of POCUS protocolization and clinical application, and the impact of POCUS at hospital and healthcare systems levels.

Keywords
artificial intelligence, cardiac arrest, governance, point-of-care ultrasound, regional anesthesia

INTRODUCTION

Since Karl Theodore Dussik first explored the diagnostic possibilities of ultrasound waves in 1942, the technology has evolved from a nascent concept into an indispensable tool of modern clinical practice. No longer confined to the radiology suite, ultrasound imaging is now widely performed at the patient's bedside by clinicians, a practice known as point-of-care ultrasound (POCUS) [1]. This paradigm shift has transformed the practice of emergency medicine, empowering clinicians with a powerful noninvasive imaging tool that is accessible, repeatable, efficient, and cost-effective [2–4].

However, the field is now at a critical inflection point. The exponential adoption of POCUS, supercharged by technological advancements like ultra-portable devices and the integration of artificial intelligence, has outpaced the development of the frameworks required to govern it. This rapid, decentralized growth has raised concerns about the shortcomings in different governance pillars including research and evidence-based medicine, particularly within the demanding, dynamic, and broad context of emergency care [5–7]. While the volume of published literature continues to grow, a clear and structured synthesis is needed to navigate this complex landscape [8].

This narrative review aims to select and summarize the most impactful recent literature on POCUS in emergency medicine. Our focus is to identify the dominant themes driving its evolution, critically examine the gaps in our collective knowledge and

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KEY POINTS

- UGRA is well tolerated and effective for rib and hip fractures.
- POCUS can improve emergent resuscitative efforts by rapidly identifying the etiology of shock, optimizing chest compression positioning, and identifying 'occult VF' which was previously not recognized as a shockable rhythm.
- POCUS has reliable diagnostic accuracy across specific cholecystitis, aortic dissection, pediatric hip effusion, and pediatric forearm fracture applications.
- Artificial intelligence-assisted image acquisition and interpretation, and device portability is improving POCUS accessibility without compromising accuracy.
- POCUS governance and administration continues to grow with multiple national guidelines and position statements providing a framework for its use.

understanding, and chart a course for the future of this transformative technology.

ULTRASOUND-GUIDED REGIONAL ANESTHESIA

Since its first recorded use, ultrasound-guided regional anesthesia (UGRA) has become a key part of emergency department clinical practice. It offers significant advantages, notably as an opiate-sparing tool for injuries like hip fractures and as a safer alternative to procedural sedation for high-risk patients [9,10▪▪]. Its safety, efficacy, and expanding applications are now dominant themes in the emergency medicine literature.

Safety and complications

The safety profile of UGRA in the emergency department is a primary concern, but recent literature is overwhelmingly reassuring. Large-scale studies confirm a very low rate of complications [9,10▪▪]. While rare neurological injury is a known risk, ultrasound guidance is believed to mitigate this [11]. Research is also extending to the safety of adjunct medications used in these blocks [12▪].

Future research must move beyond immediate complications to study long-term, patient-reported outcomes (e.g. persistent paresthesia) and establish safety in high-risk populations (e.g. coagulopathy and pediatrics).

Novel and varied approaches

Research is actively expanding UGRA's applications. For multiple rib fractures, recent randomised controlled trials (RCTs) support newer techniques like serratus anterior plane (SAP) blocks and erector spinae plane (ESP) blocks, finding them effective for pain management though there are some concerns about equipoise in these studies, and it is unclear if it would improve pulmonary complications [13▪▪,14]. For hip fractures, the trend is towards motor-sparing blocks. The pericapsular nerve group (PENG) block in particular is gaining prominence, with systematic reviews comparing it favorably to traditional femoral or fascia iliaca blocks for patient satisfaction and pain control [15–17].

The evidence base must expand beyond hip and rib fractures to other common emergency department presentations, such as shoulder or ankle injuries. More head-to-head RCTs are needed to definitively establish which blocks are superior, and if it can be used as a substitute for procedural sedation, though a recent study has found that UGRA is noninferior to Bier's block for reduction of distal radius fractures [18▪]. Furthermore, studies must evaluate efficiency metrics like emergency department length of stay, hospital length of stay, and cost-effectiveness.

ULTRASOUND-GUIDED ADVANCED RESUSCITATION

The paradigm of ultrasound-guided advanced resuscitation is becoming more established in emergency medicine. Emerging evidence shows promise that transthoracic cardiac POCUS can move us closer to individualized rather than purely protocolized approaches to advanced resuscitation.

Diagnosis in shock and cardiac arrest

The utility of POCUS in differentiating shock states is now well supported. A systematic review and meta-analysis confirmed the high diagnostic accuracy of POCUS for identifying the aetiology of shock, providing clinicians with a rapid, noninvasive tool to guide initial management [19▪]. In cardiac arrest, a key finding in recent prospective and observational studies is the detection of 'occult' ventricular fibrillation – fine ventricular fibrillation that appears as asystole on the rhythm strip [20,21▪▪]. Echocardiographic visualization of this occult ventricular fibrillation can drastically alter management by prompting defibrillation, moving the patient from a nonshockable to shockable algorithm. However, it is still unclear if cardiac arrest algorithm changes based on occult ventricular fibrillation leads to improved survival and neurological outcomes, or if any benefit is negated by the potential prolongation of pauses in compressions with the use of POCUS.

Guidance for chest compression

Beyond diagnosis, POCUS is being explored as a tool to optimize the procedure of resuscitation.

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Traditional landmark-based chest compressions may be anatomically incorrect for many patients, and a 2024 prospective observational study provided evidence that CPR performed without compressing the aortic root was associated with a higher chance of return of spontaneous circulation (ROSC) [22]. This finding strongly suggests that using POCUS to guide the location of chest compressions by avoiding the left ventricular outflow tract could be a critical, actionable step to improve resuscitation efficacy.

As these findings are observational, the critical next step is a large-scale randomized controlled trial to determine if actively using POCUS to guide compression placement improves ROSC and survival to hospital discharge compared to standard landmark-based technique. Finally, future work must focus on developing standardized training to ensure provider competency in high-stress scenarios and creating protocols that integrate these advanced POCUS skills into existing advanced life support algorithms without causing prolonged interruptions.

DIAGNOSTIC ACCURACY OF POINT-OF-CARE ULTRASOUND

The evidence for diagnostic POCUS continues to grow across emergency applications, particularly for cholecystitis, cardiac and vascular emergencies, and musculoskeletal presentations.

Cholecystitis

The most robust body of recent literature pertains to biliary disorder, with two systematic reviews and meta-analyses showing that emergency physician-performed POCUS has high sensitivity (94 and 93%, respectively) and moderate sensitivity (71 and 73%, respectively) for the diagnosis of acute cholecystitis [23▪▪,24▪]. A retrospective cohort study showed that gallbladder distention (width $\geq$4 cm or length $\geq$10 cm) was 85% specific for cholecystitis, increasing to 95% when patients had stones, distention, and sonographic Murphy's [25]. While previous studies of radiology-performed ultrasound supported distention predicting acute cholecystitis, this finding is novel in POCUS. Operationally, POCUS performed within 60 min of presentation reduced emergency department length of stay and time to surgical consultation, demonstrating the value in its timely use for suspected cholecystitis [26].

Aortic dissection

Recent evidence validates structured vascular POCUS protocols as emergent triage tools for aortic dissection. In a systematic review and meta-analysis, an intimal flap on bedside transthoracic echocardiography (TTE) in atraumatic thoracic aortic syndrome had a specificity of 92% for type A and 100% for type B dissections [27▪▪]. They also demonstrated high specificities across other indirect TTE signs including aortic valve regurgitation, thoracic aortic aneurysm, and pericardial effusion. A sonographic protocol for the emergent evaluation of aortic dissections (SPEED) was also developed, involving a parasternal long-axis cardiac view and transverse and sagittal abdominal aortic views [28▪▪]. In this prospective cohort of 1314 patients, finding a pericardial effusion, intimal flap, or aortic outflow tract diameter greater than 35 mm yielded a sensitivity of 93% for dissection. Another study found that an aortic root diameter at least 4.5 cm had a positive-predictive value of 96% for thoracic aortic aneurysm, with 15% of these patients also diagnosed with thoracic aortic dissection [29]. The PROFUNDUS study integrated the Aortic Dissection Detection (ADD) Score, POCUS findings, and d-dimer to risk stratify patients, showing that patients with low pretest probability defined as an ADD score of 0–1, no direct POCUS signs, and d-dimer less than 500 ng/ml had a sensitivity of 100% in ruling out aortic dissection [30▪▪]. The limitations of TTE are also highlighted in a systematic review showing transesophageal echocardiography is more sensitive and specific than TTE for acute aortic dissection [31]. Overall, these studies demonstrate that a structured POCUS protocol for the detection of aortic dissection is a reliable first-option when patients are too unstable for computed tomography (CT) imaging.

Musculoskeletal

Several papers explored musculoskeletal POCUS for pediatric hip effusions and distal forearm fractures. In a single-site prospective trial involving children with limb pain or new limp, emergency department physician-performed POCUS had a sensitivity of 90% and specificity of 91% for identifying hip effusion [32]. Another similar multicenter prospective study yielded a sensitivity of 89% and specificity of 99% [33]. Although 18 physicians collected scans, most were performed by only 3 physicians. A subgroup analysis showed that sensitivity and specificity is higher among physicians who scan more frequently [33].

On distal forearm fractures, a randomized controlled trial of 270 pediatric patients with suspected nondeformed distal forearm fractures found that POCUS correctly identified a buckle, other, or no fracture with 98% diagnostic accuracy compared to 83% with X-ray [34▪]. Importantly, no clinically significant fractures were missed in either group, supporting a POCUS-only approach in these cases.

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TECHNOLOGY AND ARTIFICIAL INTELLIGENCE

Recent literature highlights the emergence of artificial intelligence in POCUS and portable handhelds. While these studies are mostly preclinical, they show potential for POCUS to be used by a wider range of providers, automate image acquisition and measurements, and save costs.

Artificial intelligence

Artificial intelligence applications in POCUS show potential to improve accessibility and efficiency while reducing operator dependence. A scoping review exploring POCUS artificial intelligence implementation in clinical settings, highlighted cardiac, lung, and inferior vena cava (IVC) applications as the most common sites [35▪]. Artificial intelligence showed high diagnostic accuracy in detecting disorders such as B lines and in automating measurements such as left ventricular ejection fraction (LVEF), IVC collapsibility index (CI), and velocity time integral (VTI). Less commonly, artificial POCUS applications were used to automatically label abdominal organs, measure bladder volume, identify deep vein thrombosis, and assist with ultrasound-guided nerve blocks. Artificial intelligence POCUS was limited when interpreting poor quality images.

In lung ultrasound, artificial intelligence guidance shows potential amongst novice users after a study demonstrated that healthcare providers with artificial intelligence assistance achieved lung ultrasound images meeting diagnostic standards compared to lung ultrasound experts not utilizing artificial intelligence [36▪].

There is also promise in cardiac ultrasound, with one retrospective study using artificial intelligence AIto automatically interpret 1.2 million TTE videos, showing high accuracy for left and right ventricular dysfunction and aortic and mitral stenosis [37▪]. This algorithm was used successfully on both complete echocardiographic studies as well as abbreviated POCUS scans performed by emergency department clinicians. Artificial intelligence POCUS was also integrated in cardiac arrest by using an artificial intelligence model to quantify carotid artery compressibility and correlate it with ROSC, opening the possibility of continuous ROSC detection during compressions [38▪]. As these studies used artificial intelligence models to analyze the ultrasound data retrospectively, live implementation to inform real-time bedside decisions is the next step.

Although many studies explored the benefit of artificial intelligence for clinical applications, there are also emerging financial implications. For example, adopting artificial intelligence-assisted TTE in the emergency department to reduce downstream comprehensive TTEs in intermediate-risk syncope patients has potential annual cost savings in the United States of $815 million [39▪].

Hardware

As more portable handheld ultrasound devices come to market, the diagnostic performance of these devices is becoming a focus. Handheld and cart-based POCUS had comparable diagnostic accuracy, sensitivity, and specificity in the emergency department, despite lower image quality [40▪]. In an educational setting with 35 POCUS experts, a comparison of image quality, ease-of-use, and overall satisfaction among six commercially available handhelds found that device preference varied based on view and no single device was superior across all domains [41▪].

POINT-OF-CARE ULTRASOUND ADMINISTRATION AND GOVERNANCE

Emergency medicine societal endorsement of POCUS initially lagged behind its development and clinical implementation, but POCUS governance has since matured. The American College of Emergency Physicians (ACEP) published its most recent revision of its ultrasound guidelines in 2023 [3]. Other groups like the Australasian Emergency Medicine Ultrasound Group, Society of Point of Care Ultrasound, Healthcare Information and Management Systems Society (HIMSS), Society for Imaging Informatics in Medicine (SIIM), and American Institute of Ultrasound in Medicine (AIUM) have published position statements or white papers in the last 2 years on POCUS administration and governance [42,43,44▪]. There is consensus that POCUS is a unique skill and that POCUS studies are distinct from ultrasound studies performed via other workflows like consultative radiology or echocardiography. In general, there is agreement that privileging for POCUS should be specialty-based and dependent on the local needs of the clinical setting that it is being used. Additionally, best practice involves infrastructure and workflows supporting the documentation, archival, and quality assessment of POCUS studies. The HIMSS-SIIM white paper endorses the use of a clinical encounter-based workflow for POCUS as well as robust program, clinical, technology, information, and financial governance [44▪].

These governance considerations are particularly important in light of a recently published study about the medicolegal risks of POCUS. A group of Canadian investigators reviewed the closed-case repository for the Canadian Medical Protective Agency over a 10-year time period from 2012 to 2021 [45▪]. This is a mutual

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medical defense organization for Canadian physicians. Of 58 626 closed medicolegal cases, 15 involved POCUS as a contributing factor to the medicolegal action, with the outcome decided against the physician in all cases. For seven cases, the primary contributing factor was failure to use POCUS when indicated. However, in eight cases, POCUS was used, but there was a problem or issue with how it was used (e.g. inadequate skill, incorrect approach, problems with reporting or documentation, inappropriate use, and misdiagnosis). In the context of this literature, three prior publications searched the Westlaw legal database, a database of all United States federal and state lawsuits dating to 1939 [46–48]. These studies identified a small number of cases where POCUS was a contributing factor, and for all these cases, the issue was a failure to use POCUS when clinically indicated. This newer evidence shows the use of POCUS (in addition to failure to use POCUS when indicated) can expose clinicians to medicolegal risk. Appropriate POCUS program governance is particularly important for improving patient care and mitigating clinician risk, as POCUS should be performed by clinicians with adequate skill and scans should be clearly documented and ideally archived as part of the medical record.

CONCLUSION

Overall, the past 18 months of POCUS literature highlights its utility as an essential emergency medicine tool. UGRA shows promise in providing safe analgesia for rib and hip fractures. In resuscitation, POCUS provides diagnostic and therapeutic clarity in identifying the cause of shock and optimal chest compression positioning, while reshaping traditional advanced life support algorithms by newly characterizing 'occult VF'. Diagnostically, the reliability of POCUS continues to grow across biliary, cardiovascular, and musculoskeletal applications, while artificial intelligence integration and the availability of portable devices is making POCUS more accessible. POCUS governance and administration continues to mature, with multiple national groups publishing guidelines and position statements on best practices for POCUS program management. This is important given the emerging medicolegal implications of POCUS. In the future, POCUS can continue to grow with a greater focus on patient-oriented outcomes, POCUS protocolization, and the impact of POCUS at the hospital and healthcare systems levels.

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Conflicts of interest

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